Tire Aging Test Development Project

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Background

- **Problem Definition**
  - Tire failures resulting from thermo-oxidative degradation; a process related to:
    - Time
    - Ambient and operating temperatures
    - The partial pressure of oxygen in a tire
    - Flex-fatigue
    - Construction and compounding characteristics of each tire
  - This process is commonly referred to as “tire aging”

Background

- **Research Approach**
  - Retrieve tires from a southwestern US state (fastest aging rates) and study the rate of degradation of tire material properties and whole tire performance
  - Develop an artificial, accelerated indoor test for new tires that:
    - Simulates many years of use in states with high average ambient temperatures
    - Evaluates a tire's ability to retain of safety-critical durability properties after accelerated aging
- **Anticipated Safety Benefits**
  - Decreases in fatalities, injuries, and crashes caused by tire failures

Background

- **Annual Estimates of Crashes Resulting from "Flat Tire/Blowout" Causes***
  - 1.10 percent of all light vehicles in fatal crashes were coded with tire problems
  - 414 fatalities
  - 10,275 non-fatal injuries
  - 23,464 tow-away crashes
- **The percentage of tire failure induced crashes resulting from to age-related degradation is unknown**

** Source: 1995-98 NASS/FARS, Final Regulatory Evaluation, FMVSS No. 139 New Pneumatic Tires for Light Vehicles, " June 2003Pages III-3 – III-7,* http://dmses.dot.gov/docimages/pdf86/246849_web.pdf

Background

- **Legislative Background**
  - 11/1/2000 - TREAD Act
    - "The Secretary of Transportation shall conduct a rulemaking to revise and update the tire standards published at 49 CFR 571.109 and 49 CFR 571.119."*
    - "The agency acknowledges that, during the Firestone hearings, members of Congress suggested that an aging test could evaluate the risk of tire failure at a period later in the life of a tire than the period tested by the current endurance test."**

*PUBLIC LAW 106–414—NOV. 1, 2000, TRANSPORTATION RECALL ENHANCEMENT, ACCOUNTABILITY, AND DOCUMENTATION (TREAD) ACT

**FMVSS 139 Final Rule, http://www.nhtsa.dot.gov/cars/rules/rulings/UpgradeTire/Final/Index.html

Background

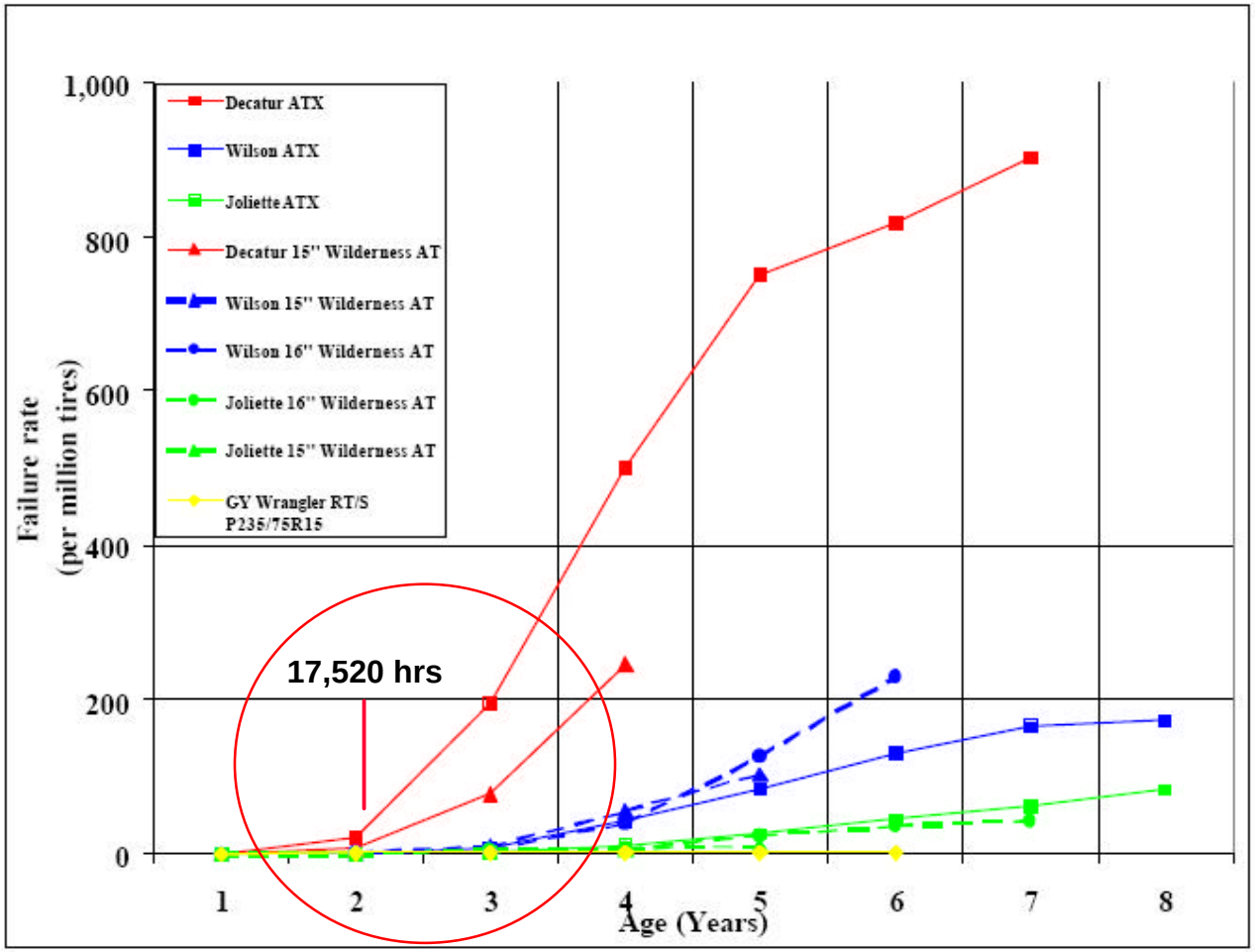


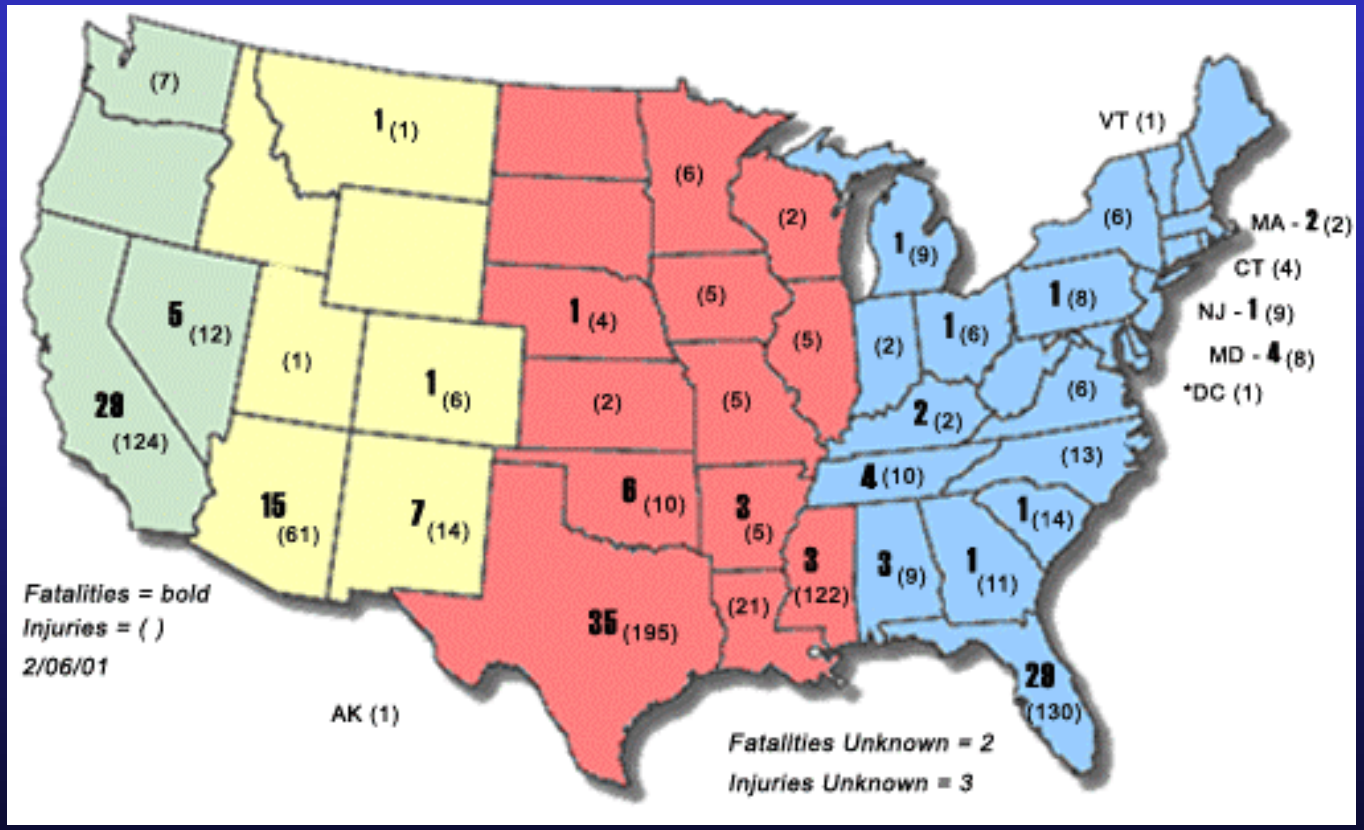
Figure 16 – Cumulative failure frequencies. Recalled and focus tires by model, size, and plant vs. Goodyear Wrangler RT/S

Firestone claims database as of March 2001
Goodyear claims as of December 2000

Engineering Analysis Report and Initial Decision Regarding EA00-023: Firestone Wilderness AT Tires U.S. Department of Transportation, National Highway Traffic Safety Administration, Safety Assurance, Office of Defects Investigation, October 2001

Background

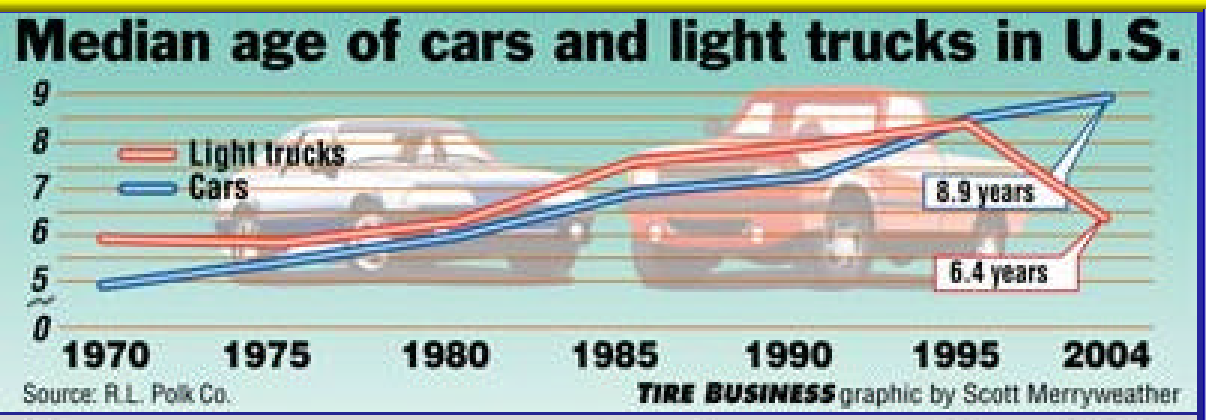
Fatalities and Injuries Resulting from Firestone Tire Failures by State



Most tire failures occurred in states touching the <u>southern border</u> of the US: CA, AZ, TX, etc.

Source: Public Citizen Firestone Tire Resource Center

Background



HydroEdge™

- Michelin HydroEdge
- UTQG: 800/A/B
- **90,000 Mile Warranty**

Research Approach

Tire Aging Test Development Project

Project Overview

Quantify How Tires Age in States with High Average Ambient Temperatures

↓

Evaluate Effectiveness of Proposed Accelerated Tire Aging Methods

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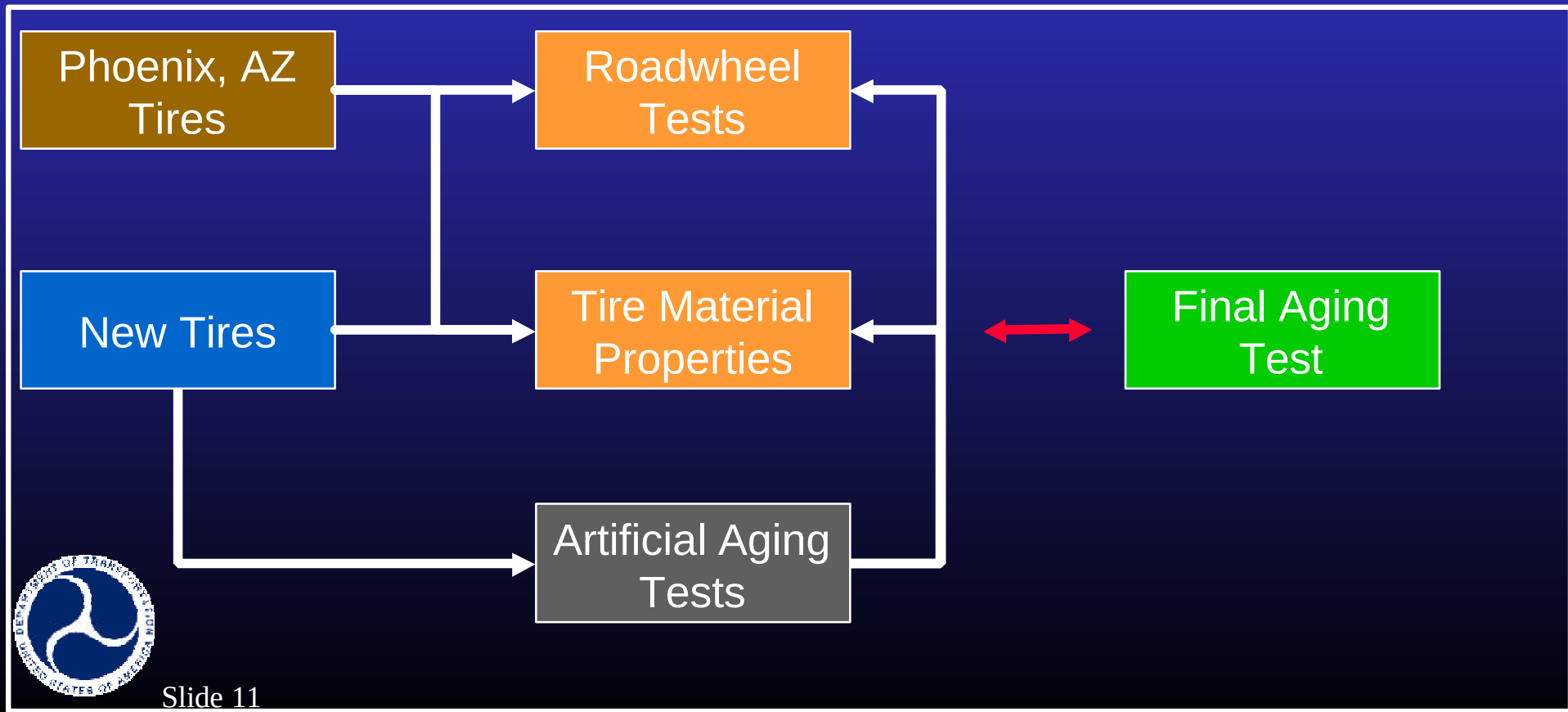
Develop an Accelerated Tire Aging Test for Tires Covered by the FMVSS 139

Research Flowchart

Over 1000 new and Phoenix, AZ field tires are being tested at three Akron, Ohio area test labs



Phoenix, AZ Tire Collection

- **Phoenix, AZ: March-April 2003**
- **Over 500 Phoenix tires collected**
- **Selection Requirements**
  - Phoenix Tires
    - In production 1998 to 2003
    - No ‘major’ design changes from 98 – 03
    - Manufacturers helped the agency select models that are sold and are performing well in the Southwestern US
  - Vehicles
    - Must be registered in Arizona with AZ license plates
    - Random sampling of the population at service centers (coming in for an oil change, tire rotation, repair, etc.)

Phoenix, AZ Tire Collection

- **Phoenix Collection**
  - The six tire models (out of 12) with the best age & mileage distribution were selected for testing
  - 6 models:
    - 4 P-metric, 1 metric, 1 LT
    - Q-V speed ratings, 89-120 load indices, 3 w cap-plies / 3 w/out
    - From varied manufacturers and vehicle applications
    - 5 OE / 1 replacement brand

Tire ID	Tire Manufacturer	Tire Model	Tire Size	Load Range	Speed Rating
B	BFGoodrich	Touring T/A SR4	P195/65R15	89	S
C	Goodyear	Eagle GA	P205/65R15	92	V
D	Michelin	LTX M/S	P235/75R15XL	108	S
E	Firestone	Wilderness AT	P265/75R16	114	S
H	Pathfinder	ATR A/S	LT245/75R16	120/116	Q
L	General	Grabber ST	255/65R16	109	H

Tire Testing

Tire Aging Test Development Project

Tire Testing - New and Used Tire Tests

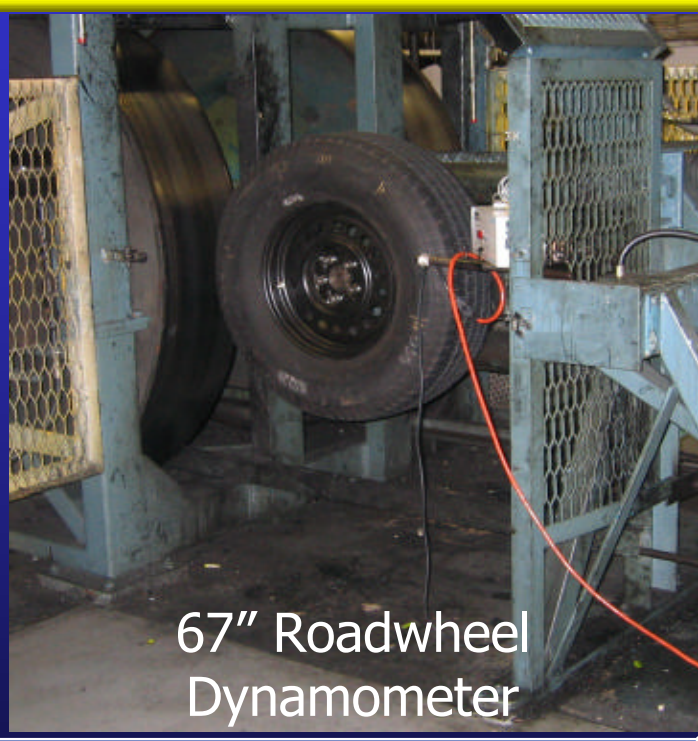
- **Whole Tire Properties**
  - Air Perm (21 & 70°C)*
  - Shearography
  - Roadwheel Dynamometer
    - Stepped-Up Load
    - Stepped-Up Speed
  - Intra-carcass Pressure*
  - Tread Depth

- **Component Properties**
  - Crosslink Density Distribution
  - Fixed Oxygen by Weight
  - Indentation Modulus
  - Innerliner Air Perm (21& 70°C)*
  - Innerliner Compound (FTIR, TGA)*
  - Interlaminar Shear
  - Micro Demattia Crack Growth
  - Microscopy
  - Peel Strength (23, 100°C)
  - Shore Hardness
  - Tensile Properties
  - Total Crosslink Density
  - Two-ply Laminate Fatigue

*New tires only

Tire Testing – Whole Tire Performance

- **Roadwheel Dynamometer:**
  - 6 models of tires
    - New tires, 58 tires
    - Phoenix tires, 148 tires
  - Two tests:



67″ Roadwheel Dynamometer

Test	Based on	Characterizes
Stepped-Up Speed to Failure*	FMVSS 139 High Speed test	Retention of high speed capacity
Stepped-Up Load to Failure*	FMVSS 139 Endurance test	Retention of load carrying capacity

Tire Testing – Whole Tire Performance

Stepped-Up Load Test: Test load stepped up through 139 Endurance conditions and on to failure, New & Used Tires

Test Stage (#)	Duration (hours)	Percent Max Load	Speed (mph)	Test
1	4	85%	75	*FMVSS 139 Endurance*
2	6	90%	75	
3	24	100%	75	
Inspection	**1**	**-**	**-**	**-**
4	4	110%	75	*Stepped-Up Load to Catastrophic Failure*
5	4	120%	75	
Etc.	4	+10% every 4 hours	75	

Note: Minor chunking / pre-existing rock chipping not a failure condition!

Tire Testing – Whole Tire Performance

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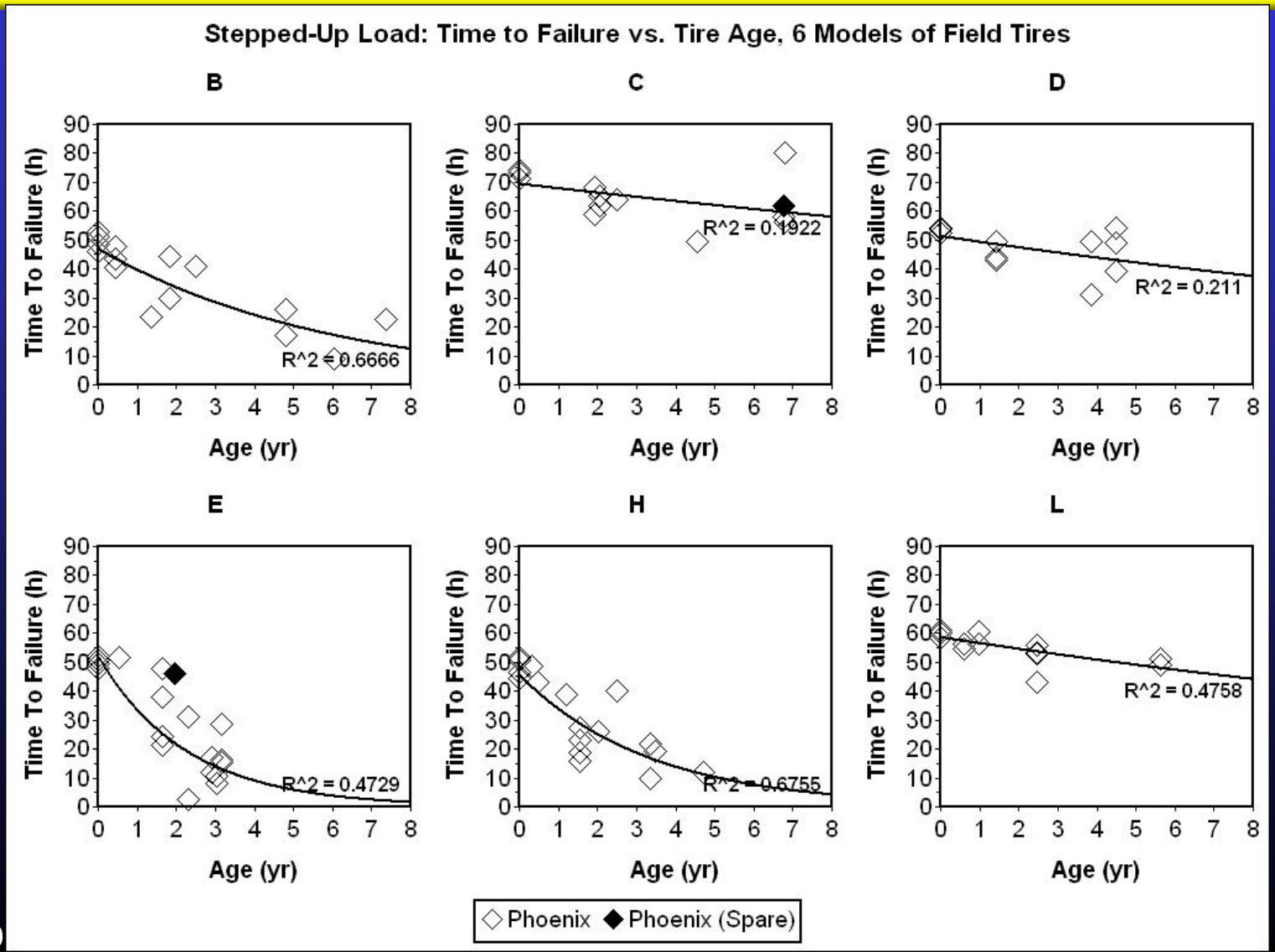
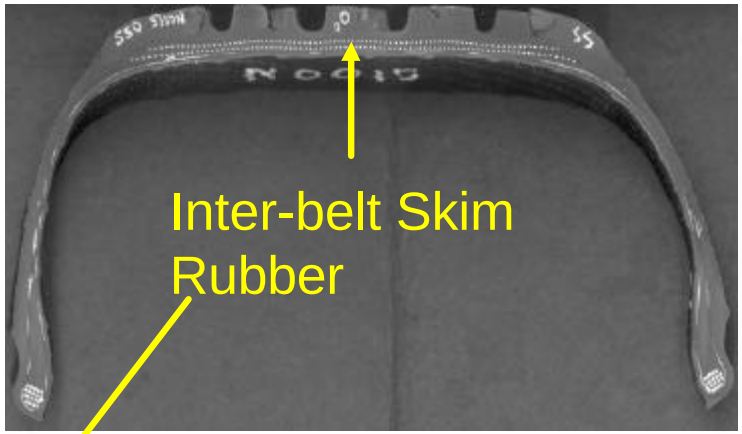
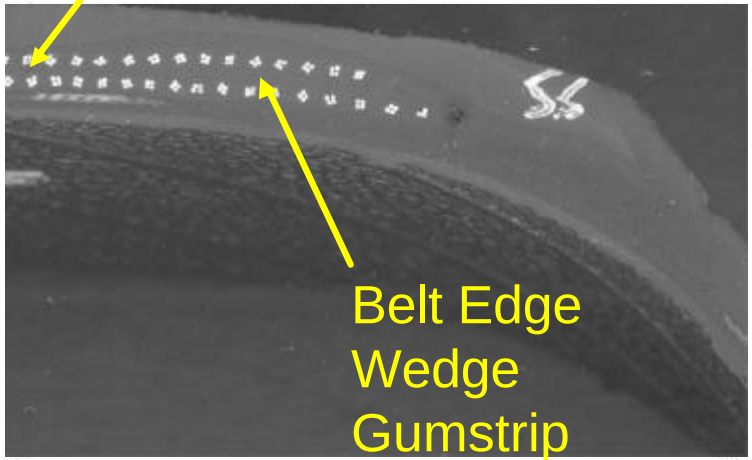
- **Roadwheel Removal Conditions**

Tire Testing – Whole Tire Performance

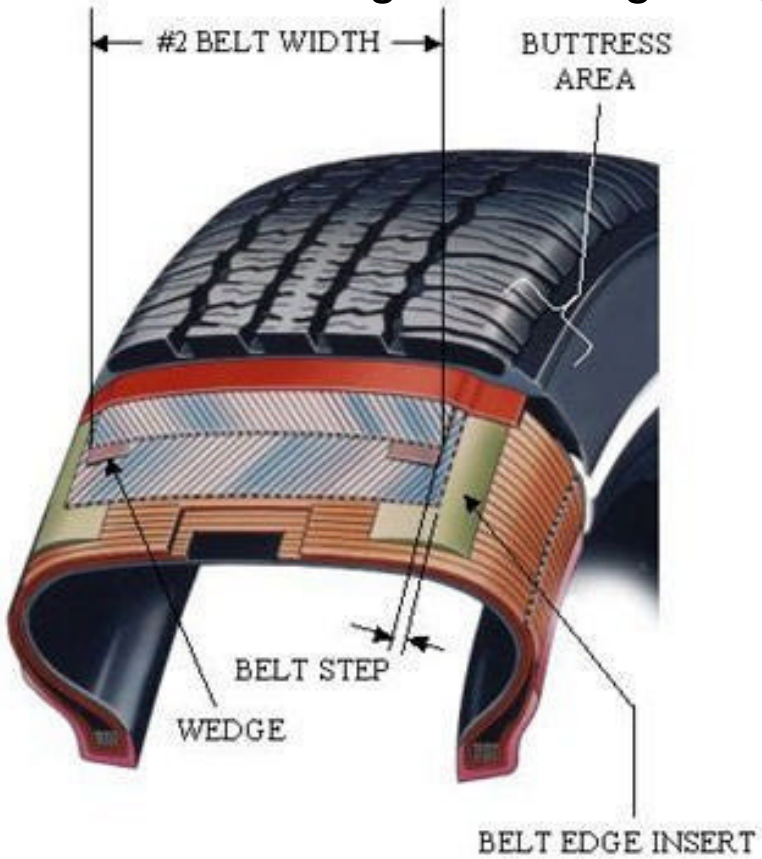


Tire Testing –Material Properties

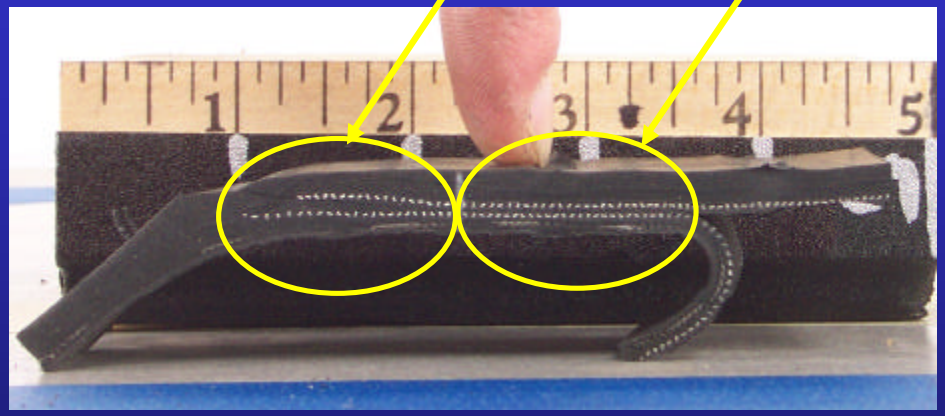


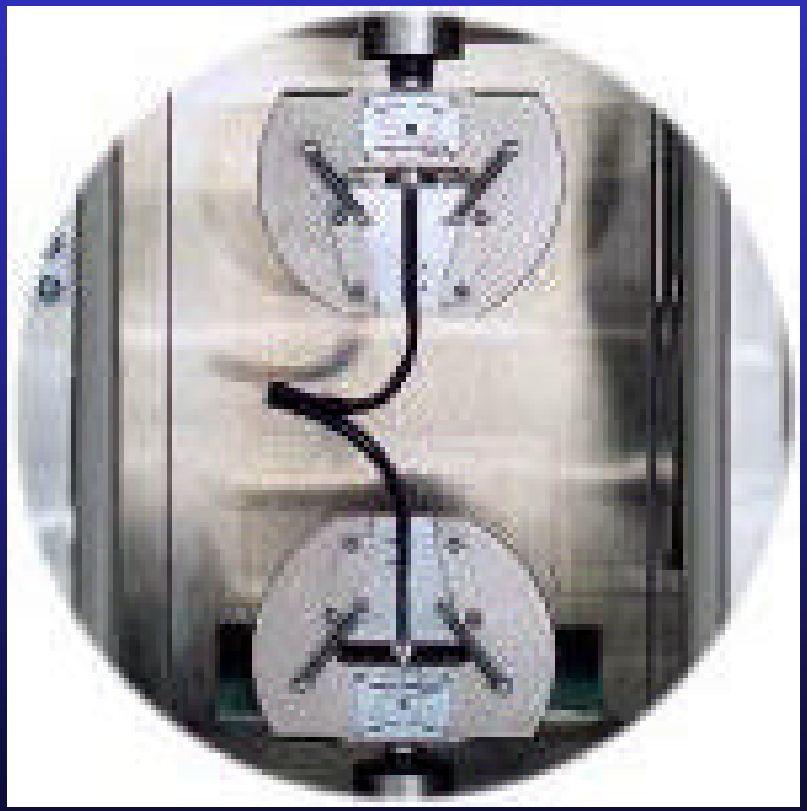


The Belt Edge Cracking



Tire Testing – Peel Strength (23 C)





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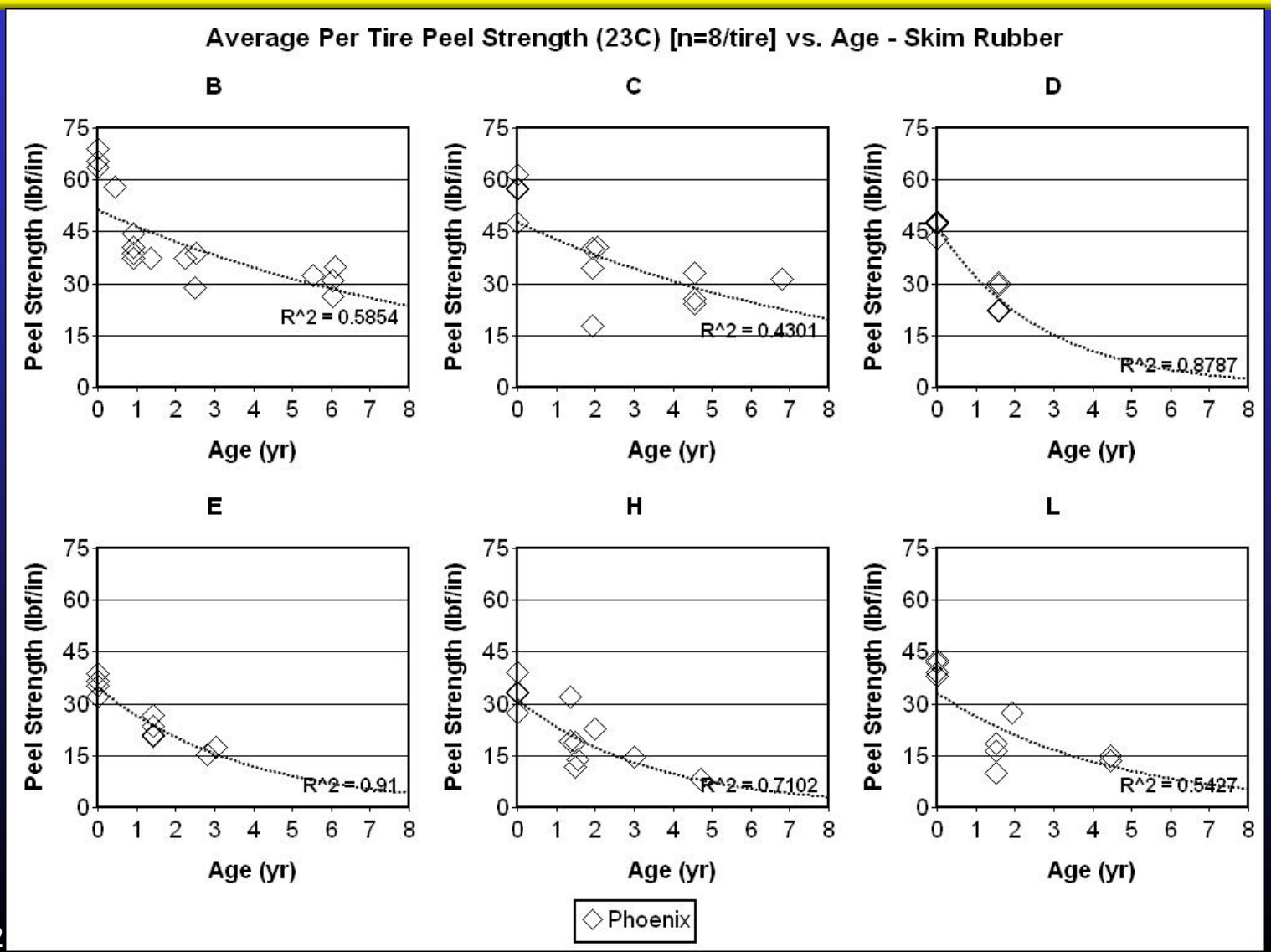

Evaluation of Indoor Accelerated Tire Aging Tests

Tire Aging Test Development Project

Evaluation of Aging Tests

- **New versions of each of the six tire models collected from Phoenix were put through three accelerated aging methods and compared to Phoenix tires:**
  - Continental General – “P-END” Roadwheel Aging Test
    - 109 Tires
  - Michelin – “LTDE” Roadwheel Aging Test
    - 146 Tires
  - Ford – Oven Aging Method
    - 105 Tires
- **Analysis of these aging methods is ongoing**

Resources

- **NHTSA Tire Aging Docket**
  - http://dms.dot.gov - Docket NHTSA-2005-21276
- **NHTSA VRTC Tire Research Webpage**
  - http://www-nrd.nhtsa.dot.gov/vrtc/ca/tires.htm
- **ASTM F09.30 Subcommittee Task Group on Tire Aging**
  - http://www.astm.org